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Description

TECHNICAL FIELD

[0001] The present invention relates to an ultrasonic diagnostic apparatus and more particularly relates to an ultrasonic diagnostic apparatus that can obtain an attribute value of a blood vessel.

BACKGROUND ART

[0002] An ultrasonic diagnostic apparatus is used to make a noninvasive checkup on a subject by irradiating him or her with an ultrasonic wave and analyzing the information contained in its reflected wave (i.e., echo). For example, a conventional ultrasonic diagnostic apparatus that has been used extensively converts the intensity of the reflected wave into its associated pixel luminance, thereby presenting the subject's structure as a tomographic image. In this manner, the internal structure of the subject can be known.

[0003] Meanwhile, some people are attempting recently to track the motion of a subject's tissue more precisely and evaluate the strain and the elasticity, viscosity or any other physical (attribute) property of the tissue (among other things, an arterial vascular wall) mainly by analyzing the phase of the reflected wave (Patent Document No. 1 or 2).

[0004] If the elastic property of each site of the arterial vascular wall under inspection is presented as a two-dimensional distribution by using such a technique, a portion of the arterial vascular wall with a unique elastic modulus can be easily identified. That is why an ultrasonic diagnostic apparatus could be used in diagnosing arterial sclerosis.

Patent Document No. 1: Japanese Patent Application Laid-Open Publication No. 10-5226

Patent Document No. 2: Japanese Patent Application Laid-Open Publication No. 2000-229078

Patent Document No. 3: Pamphlet of PCT International Application Publication No. 2004/112568

Patent Document No. 4: Japanese Patent Application Laid-Open Publication No. 2000-271117

EP 1 529 491 A1 relates to an ultrasonograph and a method for controlling ultrasonograph. The apparatus of said document comprises a fluid determining section for determining a fluid portion.

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] In presenting an attribute property value representing an elastic property, for example, as a two-dimensional distribution image, only the attribute property values at respective sites of the subject are displayed as pieces of information without reflecting any structural difference of the subject. For example, if the adventitia and

its adjacent media of an arterial vascular wall have the same tissue hardness, then their elastic moduli will also be the same, thus making no difference in the information displayed.

5 [0006] However, in order to make a more accurate pathological diagnosis on the subject, it would be more beneficial to allow the person making the diagnosis to determine what tissue of the vascular wall the region of interest belongs to.

10 [0007] In order to overcome the problems described above, the present invention has an object of providing an ultrasonic diagnostic apparatus that can selectively present the elastic modulus distribution of any arbitrary tissue in the vascular wall.

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MEANS FOR SOLVING THE PROBLEMS

[0008] An ultrasonic diagnostic apparatus according to the present invention includes: a transmitting section for driving an ultrasonic probe that sends out an ultrasonic wave toward a measuring region of a subject, the region including an arterial vascular wall; a receiving section for receiving a reflected wave, produced by getting the ultrasonic wave reflected from the subject, at the ultrasonic probe, thereby generating a received signal; a displacement detecting section for calculating the magnitude of displacement of each measuring point in the measuring region on the vascular wall by analyzing the received signal; a tissue-to-present determining section, which defines at least one boundary between multiple tissues included in the measuring region in the vascular wall and which selects one of at least two areas that have been divided by the boundary defined; and a property value calculating section for calculating a property value of the subject based on the magnitude of displacement of each said measuring point. The distribution of property values of the measuring points included in the area that has been selected by the tissue-to-present determining section is presented as a two-dimensional image.

20 [0009] In one preferred embodiment, the tissue-to-present determining section includes: a boundary defining section for defining at least one boundary between the multiple tissues included in the vascular wall; and an area selecting section for selecting one of at least two areas that have been divided by the boundary defined. The area selecting section generates the location information of the one area in accordance with an operator's command.

25 [0010] In this particular preferred embodiment, the ultrasonic diagnostic apparatus further includes: an image processing section for generating a tomographic image of the measuring region of the subject based on the received signal; and a display section for presenting the tomographic image.

30 [0011] In a specific preferred embodiment, the boundary defining section generates the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image

presented on the display section.

[0012] In another preferred embodiment, the boundary defining section automatically generates the location information of the at least one boundary based on the received signal.

[0013] In this particular preferred embodiment, the ultrasonic diagnostic apparatus further includes a storage section that stores not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

[0014] In a specific preferred embodiment, the ultrasonic diagnostic apparatus reads the information about the tomographic image from the storage section to present the tomographic image on the display section. The boundary defining section reads the location information of the at least one boundary between the tissues from the storage section. And the boundary defining section updates the location of the at least one boundary based on the location that has been specified by the operator on the tomographic image presented on the display section.

[0015] In another preferred embodiment, the boundary defining section automatically generates the location information of the at least one boundary based on the received signal, and updates the location information of the at least one boundary generated based on the location that has been specified by the operator on the tomographic image presented on the display section.

[0016] In still another preferred embodiment, the property value is an elastic modulus.

[0017] In yet another preferred embodiment, the ultrasonic diagnostic apparatus further includes a region-of-interest designating section for allowing the operator to designate a region of interest within the measuring region based on the tomographic image presented on the display section. The property value calculating section calculates a property value of the subject based on the magnitude of displacement of a measuring point inside the region of interest.

[0018] In this particular preferred embodiment, the property value calculating section further calculates at least one of the average, maximum value, minimum value and variance of elastic moduli within the region of interest.

[0019] In an alternative preferred embodiment, the property value calculating section further figures out the distribution of elastic moduli within the region of interest and presents the distribution of elastic moduli as a histogram on the display section.

[0020] In yet another preferred embodiment, the vascular wall includes an intima, a media and an adventitia and the at least one boundary is at least one of a boundary between the intima and the media, and a boundary between the media and the adventitia.

[0021] A control method according to the present in-

vention is a method for controlling an ultrasonic diagnostic apparatus using a control section of the apparatus. The method includes the steps of: (A) driving an ultrasonic probe and sending out an ultrasonic wave; (B) receiving a reflected wave from a subject, including an arterial vascular wall, at the ultrasonic probe, thereby generating a received signal; (C) calculating the magnitude of displacement of each measuring point in a measuring region on the vascular wall by analyzing the received signal; (D) defining at least one boundary between multiple tissues included in the measuring region in the vascular wall and selecting one of at least two areas that have been divided by the boundary defined; (E) calculating a property value of the subject based on the magnitude of displacement of each said measuring point; and (F) presenting the property values of the measuring points included in the at least one area as a two-dimensional image.

[0022] In one preferred embodiment, the step (D) includes the steps of: (D1) defining at least one boundary between the multiple tissues included in the vascular wall; and (D2) selecting one of the at least two areas that have been divided by the boundary defined. The step (D2) includes generating the location information of the one area in accordance with an operator's command.

[0023] In this particular preferred embodiment, the method further includes the steps of: (G) generating a tomographic image of the measuring region of the subject based on the received signal; and (H) presenting the tomographic image.

[0024] In another preferred embodiment, the step (D1) includes generating the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image.

[0025] In still another preferred embodiment, the step (D1) includes automatically generating the location information of the at least one boundary based on the received signal.

[0026] In this particular preferred embodiment, the method further includes, between the steps (D) and (E), the step (I) of storing, in the storage section, not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

[0027] In a specific preferred embodiment, the method further includes, between the steps (D) and (E), the step (J) of reading the information about the tomographic image from the storage section to present the tomographic image on the display section, and making the boundary defining section retrieve the location information of the at least one boundary between the tissues from the storage section, and the step (K) of updating the location information of the at least one boundary by allowing the operator to modify the location of the at least one boundary on the tomographic image.

EFFECTS OF THE INVENTION

[0028] According to the present invention, the boundary between arbitrary tissues in the vascular wall of a subject can be detected and a two-dimensional distribution image of elastic moduli can be presented for the tissues specified by the operator. As a result, the distribution of elastic moduli can be known, and the pathological diagnosis of the subject can be made more accurately, on a tissue-by-tissue basis within the measuring region.

BRIEF DESCRIPTION OF DRAWINGS

[0029]

FIG. 1 is a block diagram illustrating a first preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention.

FIG. 2 is a flowchart showing how the ultrasonic diagnostic apparatus shown in FIG. 1 operates.

FIG. 3 illustrates an example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 1.

FIG. 4 illustrates another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 1.

FIG. 5 illustrates still another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 1.

FIG. 6 is a block diagram illustrating a second preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention.

FIG. 7 illustrates an example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 6.

FIG. 8 illustrates another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 6.

FIG. 9 illustrates still another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 6.

FIG. 10 is a block diagram illustrating a third preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention.

FIG. 11 is a flowchart showing how the ultrasonic diagnostic apparatus shown in FIG. 10 operates.

FIG. 12 illustrates an example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 10.

FIG. 13 illustrates another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 10.

FIG. 14 illustrates still another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. 10.

DESCRIPTION OF REFERENCE NUMERALS

[0030]

5	101, 102, 103	ultrasonic diagnostic apparatus
	201	probe
	202	transmitting section
10	203	receiving section
	204	tomographic image processing section
15	205	computing section
	206	displacement detecting section
	207	property value calculating section
20	208	user interface
	209	region-of-interest designating section
25	210	tissue-to-present determining section
	211, 221, 223	boundary defining section
	212	area selecting section
30	213	image synthesizing section
	214	display section
35	250	control section
	251	memory

BEST MODE FOR CARRYING OUT THE INVENTION

(EMBODIMENT 1)

[0031] Hereinafter, a first preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention will be described. The ultrasonic diagnostic apparatus of the present invention is used to measure the elastic modulus, magnitude of strain, coefficient of viscosity or any other attribute property value of a vascular wall. In the following description of preferred embodiments, the ultrasonic diagnostic apparatus is supposed to calculate the elastic modulus as an attribute property value. Alternatively, the apparatus may also calculate the magnitudes of strains or the coefficients of viscosity and present an image representing the two-dimensional distribution thereof.

[0032] FIG. 1 is a block diagram showing a configuration for an ultrasonic diagnostic apparatus **101** as a first preferred embodiment of the present invention. The ul-

trasonic diagnostic apparatus **101** includes a transmitting section **202**, a receiving section **203**, a tomographic image processing section **204**, a computing section **205**, a region-of-interest designating section **209**, a tissue-to-present decision section **210** and an image synthesizing section **213**. The apparatus further includes a control section **250** for controlling all of these elements and a user interface **208**. The control section **250** may be implemented as a microcomputer, for example. The user interface **208** is an input device such as a keyboard, a mouse, a track ball, a switch, or a button that accepts an operator's input.

[0033] The ultrasonic diagnostic apparatus **101** is connected to a probe **201**, which sends out an ultrasonic wave toward a measuring region of a subject and receives a reflected wave, produced by getting the ultrasonic wave reflected from the subject.

[0034] In accordance with the instruction given by the control section **250**, the transmitting section **202** generates a high-voltage transmission signal that drives the probe **201** at a specified timing. The probe **201** converts the transmission signal that has been generated by the transmitting section **202** into an ultrasonic wave and sends out the ultrasonic wave toward a subject, and also converts a reflected wave that has been reflected by an internal organ of the subject into an electrical signal. A number of piezoelectric transducers are arranged in the probe **201**. By changing the piezoelectric transducers to use or the timing to apply a voltage to the piezoelectric transducers, the probe **201** controls the angle of deflection and focus of the ultrasonic waves to transmit and receive. The receiving section **203** amplifies the electrical signal that has been generated by the probe **201**, and outputs a received signal. In this manner, the receiving section **203** detects either only an ultrasonic wave that has been reflected from a predetermined point (i.e., a focused ultrasonic beam) or only an ultrasonic wave that has come from a predetermined direction (or at a predetermined angle of deflection). The ultrasonic waves are usually transmitted and received a number of times (e.g., ten plus times) a second.

[0035] The tomographic image processing section **204** includes a filter, a detector, and a logarithmic amplifier, and analyzes mainly the amplitude of the received signal, thereby sequentially generating image signals representing tomographic images of the subject. Those signals generated are output to the image synthesizing section **213**.

[0036] The image synthesizing section **213** synthesizes together the tomographic image represented by the image signal and the image representing the two-dimensional distribution of attribute property values that have been calculated by the property value calculating section **207**, and outputs the synthetic image thus obtained to the display section **214**.

[0037] The region-of-interest designating section **209** generates the location information of a target region within the measuring region, which has been designated by

the operator on the tomographic image on the display section **214** with the user interface **208**. That region designated by the operator is a target region where the attribute property value needs to be calculated, and is called a "region-of-interest". The location information of the region-of-interest thus generated is output to the image synthesizing section **213** and the property value calculating section **207**.

[0038] The tissue-to-present determining section **210** determines the location information of the target tissue for the operator where the attribute property needs to be calculated. For that purpose, the tissue-to-present determining section **210** includes a boundary defining section **211** and an area selecting section **212**. The boundary defining section **211** automatically defines the location of at least one boundary between multiple tissues included in the arterial vascular wall of the subject, thereby generating location information. The boundary location information thus generated is output to the image synthesizing section **213** so that the boundary is indicated on the tomographic image on the display section **214**.

[0039] The arterial vascular wall of the subject includes an intima, a media and an adventitia. Furthermore, outside of the adventitia, there is an extravascular tissue. And the intima is adjacent to the vascular lumen. The boundaries between these tissues can be detected automatically by a known technique (which may be the one disclosed in Patent Document No. 3 or 4). More specifically, the boundaries may be detected based on the magnitude of displacement of the measuring point that has been obtained from the displacement detecting section **206** and the amplitude intensity of the received signal that has been obtained from the tomographic image processing section **204**. If the best detection method changes according to the type of the boundary, then the boundaries may be detected by multiple different detection methods. For example, since blood is flowing inside the vascular lumen, the boundary between the vascular lumen and the intima may be detected by analyzing the received signal by the Doppler's method.

[0040] The tissue-to-present determining section **210** may detect and select the boundaries either over the entire measuring region or only the region-of-interest that has been defined within the measuring region. However, the amount of computations to be done would be the smaller if the boundaries are detected and selected within the region-of-interest.

[0041] Using the user interface **208**, the operator selects one of at least two areas that have been defined by at least one boundary being superimposed on the tomographic image. The area selecting section **212** generates the location information of the area that has been selected by the operator. The selected area's location information thus generated is output to the property value calculating section **207** to be described later.

[0042] The computing section **205** includes the displacement detecting section **206** and the property value calculating section **207**. The displacement detecting sec-

tion **206** analyzes the received signal, thereby sequentially calculating the magnitudes of displacement of the respective measuring points that have been set within the measuring region of the subject. The method of calculating the magnitudes of displacement is not particularly limited but may be any known method. To calculate the magnitude of displacement with high precision, the phase difference tracking method as disclosed in Patent Document No. 1 may be used, for example. More particularly, the magnitude of displacement of the subject's tissue in the ultrasonic wave transmitting and receiving directions may be figured out by analyzing the phase difference between the received signals.

[0043] The property value calculating section **207** calculates an attribute property value such as the magnitude of strain or elastic modulus in accordance with the location information of the region-of-interest that has been provided by the region-of-interest designating section **209** and based on the magnitudes of displacement of the measuring points within the region-of-interest. More specifically, first, the property value calculating section **207** adds the magnitude of displacement that has been calculated by the displacement detecting section **206** to the original location of each measuring point, thereby finding the location of the measuring point displaced and plotting a location change waveform representing the change of locations of each measuring point. By calculating the difference between the location change waveforms of two adjacent measuring points or two arbitrary measuring points within the measuring region, a thickness variation waveform ΔW is obtained. And by dividing the thickness variation waveform ΔW by an initial value Ws , the magnitude of strain ϵ can be obtained.

[0044] The property value calculating section **207** is further provided externally with information about the blood pressure of the subject. For example, the subject's blood pressure is measured with a blood pressure manometer and the property value calculating section **207** receives the blood pressure value from the blood pressure manometer. Supposing the difference between the highest and lowest blood pressures is identified by ΔP , the radial elastic modulus E_r is calculated by $E_r = \Delta P / \epsilon = \Delta P \cdot Ws / \Delta W$. This elastic modulus E_r is obtained between every pair of adjacent measuring points within the measuring region. As a result, a two-dimensional distribution of elastic moduli in the measuring region can be obtained. As the highest and lowest blood pressures are normally measured every cardiac cycle, the elastic modulus E_r is also measured every cardiac cycle.

[0045] The property value calculating section **207** may calculate the attribute property values either only at measuring points within the selected area, representing the tissue that the operator is interested in, or using every measuring point within the region-of-interest.

[0046] The property value calculating section **207** further obtains the maximum, minimum, average and variance values of the elastic moduli that have been measured within the selected area. Optionally, the property

value calculating section **207** may also obtain the frequency distribution of elastic moduli. These values calculated are output to the image synthesizing section **213**.

[0047] The image synthesizing section **213** receives the elastic moduli that have been calculated by the property value calculating section **207**, thereby generating an image representing the two-dimensional distribution of the elastic moduli. In this case, if the elastic moduli have been obtained only within the selected area, the image synthesizing section **213** generates the two-dimensional distribution image using every elastic modulus received from the property value calculating section **207**. On the other hand, if the property value calculating section **207** has obtained elastic moduli within the region-of-interest, then the image synthesizing section **213** receives the location information of the selected area from the tissue-to-present determining section **210** and generates the two-dimensional distribution image only within the selected area.

[0048] The two-dimensional distribution image of elastic moduli thus generated is synthesized with the tomographic image of the subject's measuring region, which has been provided by the tomographic image processing section **204**. The image synthesizing section **213** also receives the location information of the region-of-interest from the region-of-interest designating section **209** and the location information of the boundary from the tissue-to-present determining section **210**, thereby generating line segments representing the region-of-interest and the boundary, respectively, and synthesizing those line segments with the tomographic image.

[0049] Furthermore, the image synthesizing section **213** generates numerical values representing the maximum, minimum, average and variance values of the elastic moduli that have been obtained by the property value calculating section **207**. If a frequency distribution of the elastic moduli has been obtained, a histogram of the elastic moduli is generated.

[0050] On the other hand, if the property value calculating section **207** has not calculated the elastic moduli yet, then line segments representing the region-of-interest and the boundary are generated and synthesized with the tomographic image.

[0051] The display section **214** receives and displays the image information that has been generated by the image synthesizing section **213**.

[0052] It should be noted that the respective elements of the ultrasonic diagnostic apparatus **101** described above could be implemented as hardware components or by a software program. The region designating section **209** and the tissue-to-present determining section **210** may be implemented by a microcomputer including the control section **250**.

[0053] Hereinafter, it will be described with reference to FIG. 1 and FIGS. 2 to 5 how the ultrasonic diagnostic apparatus **101** operates. FIG. 2 is a flowchart showing the procedure of operation of the ultrasonic diagnostic apparatus **101**. FIGS. 3 to 5 illustrate exemplary images

to be presented on the display section **214**.

[0054] First, the transmitting section **202** drives the probe **201**, thereby sending out an ultrasonic wave toward a subject including his or her arterial vascular wall. Then, a reflected wave, produced by getting the ultrasonic wave reflected by the subject, is received at the receiving section **203** through the probe **201**, thereby generating a received signal in Step **S101**.

[0055] The tomographic image processing section **204** receives the received signal and transforms the amplitude of the received signal into luminance information, thereby generating an image signal representing a tomographic image (in Step **S102**). Then, the image signal is output to the display section **214** by way of the image synthesizing section **213**, and the tomographic image is presented on the display section (in Step **S103**).

[0056] As shown in FIG. 3, a tomographic image **301** is presented on the screen of the display section **214**. The tomographic image **301** includes the intima **311**, media **312** and adventitia **313** of a vascular anterior wall, the intima **321**, media **322** and adventitia **333** of a vascular posterior wall, a vascular lumen **310**, and extravascular tissues **314** and **334**. In FIG. 3, the boundaries between these tissues are represented by line segments. In an actual tomographic image, these tissues are presented with luminances representing the intensities of the reflected ultrasonic waves. That is why the boundaries between those tissues may sometimes be not so clearly defined.

[0057] While the tomographic image is being generated, the displacement detecting section **206** of the computing section **205** analyzes the received signal, thereby calculating the magnitudes of displacements of respective measuring points within the measuring region of the subject (in Step **S104**).

[0058] The operator defines a region-of-interest **302** on the tomographic image **301** presented on the display section **214** using a user interface **208** such as a mouse. In the example illustrated in FIG. 3, the region-of-interest **302** is defined by the operator so as to include an atheroma **335** that is observed on the vascular posterior wall. In accordance with the signal that has been entered through the user interface **208**, the ROI designating section **209** determines the location information of the region-of-interest **302** within the measuring region (in Step **S105**). Optionally, the region-of-interest may also be defined after a target area where an attribute property value needs to be calculated has been selected.

[0059] The boundary defining section **211** of the tissue-to-present determining section **210** automatically detects the boundaries between the respective tissues, which are included in the arterial vascular wall, within the region-of-interest **302** based on the received signal. The location information of the boundaries detected is passed to the image synthesizing section **213** and then displayed on the display section **214**. As shown in FIG. 3, within the region-of-interest **302**, the boundary **303a** between the vascular lumen **310** and the intima **321**, the boundary

303b between the intima **321** and the media **322**, the boundary **303c** between the media **322** and the adventitia **333**, and the boundary **303d** between the adventitia **333** and the extravascular tissue **334** are superimposed on the tomographic image **301**.

[0060] Then, the operator chooses one of the areas **306A**, **306B**, **306C**, **306D** and **306E**, which have been defined by these boundaries **303a** through **303d**, as a target area where the attribute property value needs to be calculated. By moving the cursor **305** with the user interface **208** as shown in FIG. 3, for example, the operator designates one particular area. In accordance with the signal supplied from the user interface **208**, the area selecting section **212** generates the location information of the selected area that has been designated by the operator and outputs the information to the property value calculating section **207** and the image synthesizing section **213** (in Step **S107**).

[0061] Based on the magnitudes of displacement at the respective measuring points that have been provided by the displacement detecting section **206** and the location information of the selected area that has been provided by the tissue-to-present determining section **210**, the property value calculating section **207** calculates the elastic modulus between the measuring points within the selected area. The property value calculating section **207** also obtains the maximum, minimum and average values and frequency distribution of the elastic moduli within the selected area (in Step **S108**).

[0062] The image synthesizing section **213** generates a two-dimensional distribution image based on the elastic moduli that have been calculated by the property value calculating section **207** and synthesizes the distribution image and the tomographic image together (in Step **S109**). The image synthesizing section **213** also generates numerical values representing the maximum, minimum and average values and further generates a histogram of the elastic moduli. The image thus generated is presented on the display section **214** (in Step **S110**).

[0063] After that, either the region-of-interest or the selected area where the attribute property value needs to be obtained may be modified or changed if necessary. In that case, the same series of processing steps that starts with Step **S105** should be carried out all over again.

[0064] In FIG. 3, if the operator has selected the area **306C** interposed between the boundaries **303b** and **303c**, then a two-dimensional distribution image **341** of elastic moduli within the area **306C** is superimposed on the tomographic image **301** as shown in FIG. 4. The area **306C** is portion of the designated region-of-interest **302** that represents the media of the vascular posterior wall. In FIG. 4, the two-dimensional distribution image **335** is indicated by even shadowing. Actually, however, the two-dimensional distribution image **335** is presented in color tones or grayscale tones associated with the elastic moduli, and a color bar **309** or a grayscale bar **309** representing the correspondence between the elastic moduli and the color tones or grayscale tones is also displayed. The

measuring points are set in the entire region-of-interest **302** such that the distribution of elastic moduli can be presented as a two-dimensional matrix consisting of 64 vertical pixels by 32 horizontal pixels, for example.

[0065] On the other hand, if the operator has selected the area **306D** interposed between the boundaries **303c** and **303d** in FIG. 3, then a two-dimensional distribution image **342** of elastic moduli within the area **306D** is superimposed on the tomographic image **301** as shown in FIG. 5. The area **306D** is a portion of the designated region-of-interest **302** that represents the adventitia of the vascular posterior wall.

[0066] By displaying the distributions of elastic moduli on a tissue-by-tissue basis as shown in FIGS. 4 and 5, it becomes clearer what tissue a portion with a specific elastic modulus belongs to. As a result, a person who is carrying out the diagnosis (such as a doctor) can estimate the elastic moduli with the tissue-by-tissue properties into consideration. Thus, according to this preferred embodiment, a boundary between tissues in a subject can be located automatically, and an image representing the two-dimensional distribution of elastic moduli can be presented for a tissue specified by the operator. Consequently, the distribution of elastic moduli can be known for every tissue within the measuring region, and a more accurate pathological diagnosis can be made on the given subject.

[0067] In the preferred embodiment described above, the boundary defining section **211** locates the boundaries between the respective tissues that form the vascular wall. However, a plurality of tissues may be detected collectively. For example, the intima and the media may be detected as an intima-media thickness (IMT) and the boundary between the IMT and the adventitia and the boundary between the IMT and the vascular lumen may be located.

(EMBODIMENT 2)

[0068] Hereinafter, a second preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention will be described. FIG. 6 is a block diagram showing a configuration for an ultrasonic diagnostic apparatus **102** as a second preferred embodiment of the present invention. Unlike the first preferred embodiment, the ultrasonic diagnostic apparatus **102** includes a tissue-to-present determining section **220** including the boundary defining section **221**.

[0069] The boundary defining section **221** defines the at least one boundary by the location that has been specified by the operator on the tomographic image **301** being presented on the display section **214**, and generates its location information. More specifically, using the user interface **208**, the operator moves the cursor on the tomographic image **301** being presented on the display section **214**. The trace of the cursor on the move is superimposed as a line segment on the tomographic image **301**. If the operator finds the line segment drawn appro-

priately, then he or she determines his or her selection with the user interface **208**, thereby fixing the boundary that has been specified by him or her. If necessary, one or more line segments may be drawn and fixed as additional boundaries. The boundary defining section **221** generates the location information of the boundaries that have been fixed by the operator in this manner. The line segments may be drawn either in the entire measuring region or only within the region-of-interest. However, it would be less troublesome for the operator to draw a line segment, representing the boundary, only within the region-of-interest.

[0070] Subsequently, using the user interface **208** again, the operator selects one of multiple areas that have been defined by the boundary being superimposed on the tomographic image on the display section **214**. Then, the area selecting section **212** generates the location information of that area selected by the operator. The selected area location information thus generated is then output to the property value calculating section **207**.

[0071] The ultrasonic diagnostic apparatus **102** operates just as the first preferred embodiment described above except that a boundary between tissues is defined manually by the operator within either the measuring region or the region-of-interest.

[0072] FIG. 7 illustrates how the operator have fixed boundaries **303'a**, **303'b**, **303'c** and **303'd** by drawing line segments between the respective tissues with the cursor **305** moved using the user interface **208**.

[0073] In FIG. 7, if the operator has selected the area **306C** interposed between the boundaries **303'b** and **303'c**, then a two-dimensional distribution image **341** of elastic moduli within the area **306C** is superimposed on the tomographic image **301** as shown in FIG. 8. On the other hand, if the operator has selected the area **306D** interposed between the boundaries **303'c** and **303'd** in FIG. 7, then a two-dimensional distribution image **342** of elastic moduli within the area **306D** is superimposed on the tomographic image **301** as shown in FIG. 9.

[0074] Thus, according to this preferred embodiment, a boundary between tissues in a subject is drawn manually by the operator and one of the areas divided by the boundary is selected, thereby getting a two-dimensional distribution image of elastic moduli presented for any desired tissue. In particular, since the operator draws the boundary manually in this preferred embodiment, a target area where the elastic modulus needs to be calculated may be determined both arbitrarily and easily by collectively selecting a plurality of tissues as a single area and by getting the two-dimensional distribution image of elastic moduli presented in that selected area, for example. Also, even if the boundary between tissues has become locally indefinite on the tomographic image **301**, the boundary can still be defined according to the operator's own judgment. That is why it is possible to avoid the unwanted situation where such an indefinite boundary prevents the operator from finding his or her target area and obtaining a two-dimensional distribution image of elastic

moduli. Consequently, the distribution of elastic moduli can be known for every tissue within the measuring region and a more accurate pathological diagnosis can be made on the subject.

(EMBODIMENT 3)

[0075] Hereinafter, a third preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention will be described. FIG. 10 is a block diagram showing a configuration for an ultrasonic diagnostic apparatus 103 as a third preferred embodiment of the present invention. Unlike the first preferred embodiment described above, the ultrasonic diagnostic apparatus 102 includes a memory 251 functioning as a storage section and a tissue-to-present determining section 220 including a boundary defining section 231.

[0076] While an ultrasonic wave is being transmitted or received to carry out measurements, the memory 251 stores information about an image signal representing the tomographic image, which has been provided by the tomographic image processing section 204, and information about the magnitude of displacement at each measuring point, which has been provided by the displacement detecting section 206, in association with the time or order of reception of the received signals. The memory 251 also stores the location information of the boundaries that have been defined by the boundary defining section 231.

[0077] In calculating an elastic modulus by reading the information that is stored in the memory section after the measuring process has ended or suspended (or frozen) (which is also called a "cine-mode"), the image information of the tomographic image and the information about the magnitude of displacement at each measuring point, which are stored in the memory 251, are read from the memory 251 and supplied to the image synthesizing section 213 and the property value calculating section 207, respectively, at the same time in accordance with a command given by the operator. In addition, the location information of the boundary is also read from the memory 251 and supplied to the boundary defining section 231.

[0078] While transmitting or receiving an ultrasonic wave and making a measurement, the boundary defining section 231 automatically detects the boundary between tissues based on the received signal as already described for the first preferred embodiment, thereby outputting its location information. Also, in calculating an elastic modulus by reading out the information stored, the operator can modify the boundary that has been read out from the memory 251 using the user interface 208. The modification includes deleting the boundary. If the boundary has been modified by the operator, the boundary defining section 231 obtains the location information of the modified boundary and updates the location information.

[0079] Then, based on the location information of the updated boundary, the operator selects a target area

where the two-dimensional distribution of elastic moduli needs to be obtained as already described for the first preferred embodiment, thereby producing an image representing the two-dimensional distribution of elastic moduli in the selected area.

[0080] Hereinafter, it will be described with reference to FIG. 10 and FIGS. 11 to 14 how the ultrasonic diagnostic apparatus 103 operates. FIG. 11 is a flowchart showing the procedure of operation of the ultrasonic diagnostic apparatus 103. FIGS. 12 to 14 illustrate exemplary images to be presented on the display section 214.

[0081] First, the transmitting section 202 drives the probe 201, thereby sending out an ultrasonic wave toward a subject including his or her arterial vascular wall. Then, a reflected wave, produced by getting the ultrasonic wave reflected by the subject, is received at the receiving section 203 through the probe 201, thereby generating a received signal in Step S111.

[0082] The tomographic image processing section 204 receives the received signal and transforms the amplitude of the received signal into luminance information, thereby generating an image signal representing a tomographic image (in Step S112). Then, the image signal is output to the display section 214 by way of the image synthesizing section 213, and the tomographic image is presented on the display section (in Step S113).

[0083] As shown in FIG. 14, a tomographic image 301 is presented on the screen of the display section 214. The tomographic image 301 includes the intima 311, media 312 and adventitia 313 of a vascular anterior wall, the intima 321, media 322 and adventitia 323 of a vascular posterior wall, a vascular lumen 310, and extravascular tissues 314 and 334.

[0084] While the tomographic image is being generated, the displacement detecting section 206 of the computing section 205 analyzes the received signal, thereby calculating the magnitudes of displacements of respective measuring points within the measuring region of the subject (in Step S115).

[0085] The operator defines a region-of-interest 302 using a user interface 208 such as a mouse. In the example illustrated in FIG. 12, the region-of-interest 302 is defined by the operator so as to include an atheroma 335 that is observed on the vascular posterior wall. In accordance with the signal that has been entered through the user interface 208, the ROI designating section 209 determines the location information of the region-of-interest 302 within the measuring region (in Step S116). Optionally, the region-of-interest may also be defined after a target area where an attribute property value needs to be calculated has been selected.

[0086] The measuring process is carried out in such a state for a predetermined period of time, thereby obtaining measuring data. The image information to be generated sequentially and the magnitudes of displacements of the respective measuring points are stored in the memory 21 in association with the reception times (in Steps S114 and S118). The location information of the bound-

ary that has been detected automatically is also stored.

[0087] When the measuring process ends, the image information, the magnitudes of displacements of the respective measuring points, and the location information of the boundary, which have been stored in the memory 251, are read out. And the image information and the boundary are presented on the display section 214.

[0088] If necessary, the operator modifies the automatically detected boundary on the tomographic image 301 being presented on the display section 214. In FIG. 12, a portion 303e of the automatically detected boundary 303a expands toward the vascular lumen 310. If the operator has determined, based on the tomographic image 301, that the location of that portion 303e of the boundary is a detection error, then he or she modifies the location of that portion 303e of the boundary by moving the cursor 305 as shown in FIG. 13. Once the boundary has been modified, the boundary defining section 231 updates the location information of that boundary modified (in Step S120).

[0089] Then, the operator chooses one of the areas 306A, 306B, 306C, 306D and 306E, which have been defined by the modified boundary 303a and the other boundaries 303b through 303d, as a target area where the attribute property value needs to be calculated. By moving the cursor 305 with the user interface 208 as shown in FIG. 13, for example, the operator designates one particular area. In accordance with the signal supplied from the user interface 208, the area selecting section 212 generates the location information of the selected area that has been designated by the operator and outputs the information to the property value calculating section 207 and the image synthesizing section 213 (in Step S121).

[0090] Based on the magnitudes of displacement at the respective measuring points that have been provided by the displacement detecting section 206 and the location information of the selected area that has been provided by the tissue-to-present determining section 210, the property value calculating section 207 calculates the elastic modulus between the measuring points within the selected area. The property value calculating section 207 also obtains the maximum, minimum and average values and frequency distribution of the elastic moduli within the selected area (in Step S122).

[0091] The image synthesizing section 213 generates a two-dimensional distribution image based on the elastic moduli that have been calculated by the property value calculating section 207 and synthesizes the distribution image and the tomographic image together. The image synthesizing section 213 also generates numerical values representing the maximum, minimum and average values and further generates a histogram of the elastic moduli in Step S123. The image thus generated is presented on the display section 214 (in Step S126).

[0092] After that, the selected area where the attribute property value needs to be obtained may be modified or changed if necessary. In that case, the same series of

processing steps that starts with Step S121 should be carried out all over again.

[0093] In FIG. 13, if the operator has selected the area 306B interposed between the boundaries 303a and 303b, then a two-dimensional distribution image 343 of elastic moduli within the area 306B is superimposed on the tomographic image 301 as shown in FIG. 14. The area 306B is a portion of the designated region-of-interest 302 that represents the intima of the vascular posterior wall. Since the operator has modified the boundary 303a, the elastic modulus of only the intima portion is displayed properly. Although not shown in FIG. 14, the maximum, minimum and average values of elastic moduli in the selected area and histograms of the elastic moduli may also be displayed as in the first and second preferred embodiments described above.

[0094] As described above, according to this preferred embodiment, when the elastic modulus is calculated by reading information from the memory in the cine-mode after the boundary between tissues in the subject has been detected automatically, the operator can modify the automatically detected boundary. Thus, the operator can save the trouble of drawing the boundary by him- or herself and can modify the boundary manually if necessary. As a result, the target tissue, of which the elastic modulus needs to be calculated, can be determined more easily and more accurately, and the distribution of elastic moduli can be known for every tissue within the measuring region. Consequently, a pathological diagnosis can be made on the subject more accurately.

[0095] In the preferred embodiment described above, the boundary defining section 231 is designed so as to automatically detect the boundary between tissues first, read the data from the memory, and then allow the operator to modify the detected boundary if necessary. Likewise, the boundary defining section of the first preferred embodiment described above may also be designed so as to automatically detect the boundary and then allow the operator to modify the boundary if necessary. More specifically, the boundary defining section 211 may automatically generate the location information of at least one boundary based on the received signal. Then, the operator may modify and update the location information of the at least one boundary, which has been generated by the boundary defining section 211, based on the location specified by the operator on the tomographic image being presented on the display section 214. As a result, the boundary can be defined more accurately and the burden on the operator can be lightened, too.

INDUSTRIAL APPLICABILITY

[0096] The present invention can be used effectively in an ultrasonic diagnostic apparatus for measuring an attribute property value of a blood vessel.

Claims**1.** An ultrasonic diagnostic apparatus comprising:

a transmitting section (202) for driving an ultrasonic probe that sends out an ultrasonic wave toward a measuring region of a subject, the region including an arterial vascular wall;
 a receiving section (203) for receiving a reflected wave, produced by getting the ultrasonic wave reflected from the subject, at the ultrasonic probe, thereby generating a received signal;
 a displacement detecting section (206) for calculating the magnitude of displacement of each measuring point in the measuring region on the vascular wall by analyzing the received signal;
 a tissue-to-present determining section (210), which defines at least one boundary between multiple tissues in the vascular wall which are included in the measuring region, and which selects one of at least two areas that have been divided by the boundary defined; and
 a property value calculating section (207) for calculating a property value of the subject based on the magnitude of displacement of each said measuring point,
 wherein the apparatus is configured to present the distribution of property values of the measuring points included in the area that has been selected by the tissue-to-present determining section as a two-dimensional image.

2. The ultrasonic diagnostic apparatus of claim 1, wherein the tissue-to-present determining section (210) includes: a boundary defining section for defining at least one boundary between the multiple tissues included in the vascular wall; and an area selecting section (212) for selecting one of at least two areas that have been divided by the boundary defined, and wherein the area selecting section generates the location information of the one area in accordance with an operator's command.

3. The ultrasonic diagnostic apparatus of claim 2, further comprising:

an image processing section for generating a tomographic image of the measuring region of the subject based on the received signal; and
 a display section (214) for presenting the tomographic image.

4. The ultrasonic diagnostic apparatus of claim 3, wherein the boundary defining section generates the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image presented on the

display section (214).

5. The ultrasonic diagnostic apparatus of claim 3, wherein the boundary defining section automatically generates the location information of the at least one boundary based on the received signal.

6. The ultrasonic diagnostic apparatus of claim 5, further comprising a storage section that stores not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

7. The ultrasonic diagnostic apparatus of claim 6, wherein the information about the tomographic image is read from the storage section to present the tomographic image on the display section (214), and the boundary defining section reads the location information of the at least one boundary between the tissues from the storage section, and wherein the boundary defining section updates the location of the at least one boundary based on the location that has been specified by the operator on the tomographic image presented on the display section (214).

8. The ultrasonic diagnostic apparatus of claim 3, wherein the boundary defining section automatically generates the location information of the at least one boundary based on the received signal, and updates the location information of the at least one boundary generated based on the location that has been specified by the operator on the tomographic image presented on the display section (214).

9. The ultrasonic diagnostic apparatus of claim 1, wherein the property value is an elastic modulus.

10. The ultrasonic diagnostic apparatus of claim 1, further comprising a region-of-interest designating section (209) for allowing the operator to designate a region of interest within the measuring region based on the tomographic image presented on the display section, and wherein the property value calculating section (207) calculates a property value of the subject based on the magnitude of displacement of a measuring point inside the region of interest.

11. The ultrasonic diagnostic apparatus of claim 10, wherein the property value calculating section (207) further calculates at least one of the average, maximum value, minimum value and variance of elastic moduli within the region of interest.

12. The ultrasonic diagnostic apparatus of claim 10, wherein the property value calculating section (207) further figures out the distribution of elastic moduli within the region of interest and presents the distribution of elastic moduli as a histogram on the display section.

13. The ultrasonic diagnostic apparatus of claim 1, wherein the vascular wall includes an intima, a media and an adventitia and wherein the at least one boundary is at least one of a boundary between the intima and the media, and a boundary between the media and the adventitia.

14. A method for controlling an ultrasonic diagnostic apparatus using a control section of the apparatus, the method comprising the steps of:

A) driving an ultrasonic probe (201) and sending out an ultrasonic wave;

B) receiving a reflected wave from a subject, including an arterial vascular wall, at the ultrasonic probe (201), thereby generating a received signal;

C) calculating the magnitude of displacement of each measuring point in a measuring region on the vascular wall by analyzing the received signal;

D) defining at least one boundary between multiple tissues in the vascular wall, which are included in the measuring region, and selecting one of at least two areas that have been divided by the boundary defined;

E) calculating a property value of the subject based on the magnitude of displacement of each said measuring point; and

F) presenting the property values of the measuring points included in the at least one area as a two-dimensional image.

15. The method of claim 14, wherein the step D) includes the steps of:

D1) defining at least one boundary between the multiple tissues included in the vascular wall; and

D2) selecting one of the at least two areas that have been divided by the boundary defined, and wherein the step D2) includes generating the location information of the one area in accordance with an operator's command.

16. The method of claim 15, further comprising the steps of:

G) generating a tomographic image of the measuring region of the subject based on the received signal; and

H) presenting the tomographic image.

17. The method of claim 14, wherein the step D1) includes generating location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image.

18. The method of claim 16, wherein the step D1) includes automatically generating the location information of the at least one boundary based on the received signal.

19. The method of claim 18, further comprising, between the steps D) and E), the step (I) of storing, in the storage section, not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

20. The method of claim 19, further comprising, between the steps D) and E), the step J) of reading the information about the tomographic image from the storage section to present the tomographic image on the display section, and making the boundary defining section retrieve the location information of the at least one boundary between the tissues from the storage section, and the step k) of updating the location information of the at least one boundary by allowing the operator to modify the location of the at least one boundary on the tomographic image.

Patentansprüche

1. Ultraschall Diagnosevorrichtung, umfassend:

einen Übertragungsabschnitt (202) zum Betreiben einer Ultraschallsonde, die eine Ultraschallwelle hin zu einem Messbereich eines Objektes aussendet, wobei der Bereich eine arterielle Gefäßwand beinhaltet;

einen Empfangsabschnitt (203) zum Empfangen einer reflektierten Welle, die durch Aufnehmen der von dem Objekt reflektierten Ultraschallwelle erzeugt wird, an der Ultraschallsonde, wodurch ein empfangenes Signal erzeugt wird;

einen Verschiebungserfassungsabschnitt (206) zum Berechnen der Größe der Verschiebung eines jeden Messpunktes in dem Messbereich an der Gefäßwand durch Analysieren des empfangenen Signals;

einen Präsentationsgewebebestimmungsabschnitt (210), der wenigstens eine Grenze zwischen mehreren Geweben in der Gefäßwand,

- die in dem Messbereich beinhaltet sind, festlegt und der eines von wenigstens zwei Gebieten auswählt, die von der festgelegten Grenze getrennt worden sind; und
einen Eigenschaftswertberechnungsabschnitt (207) zum Berechnen eines Eigenschaftswertes des Objektes auf Grundlage der Größe der Verschiebung eines jeden Messpunktes, wobei die Vorrichtung dafür ausgelegt ist, die Verteilung von Eigenschaftswerten der Messpunkte, die in dem Gebiet beinhaltet sind, das von dem Präsentationsgewebebestimmungsabschnitt ausgewählt worden ist, als zweidimensionales Bild zu präsentieren.
2. Ultraschalldiagnosevorrichtung nach Anspruch 1, wobei der Präsentationsgewebebestimmungsabschnitt (210) beinhaltet:
- einen Grenzfestlegeabschnitt zum Festlegen wenigstens einer Grenze zwischen den mehreren Geweben, die in der Gefäßwand beinhaltet sind; und
einen Gebietsauswahlabschnitt (212) zum Auswählen eines von wenigstens zwei Gebieten, die von der festgelegten Grenze getrennt worden sind, und
wobei der Gebietsauswahlabschnitt die Ortsinformation des einen Gebietes entsprechend einem Bedienerbefehl erzeugt.
3. Ultraschalldiagnosevorrichtung nach Anspruch 2, des Weiteren umfassend:
- einen Bildverarbeitungsabschnitt zum Erzeugen eines tomografischen Bildes des Messbereiches des Objektes auf Grundlage des empfangenen Signals; und
einen Anzeigeabschnitt (214) zum Präsentieren des tomografischen Bildes.
4. Ultraschalldiagnosevorrichtung nach Anspruch 3, wobei der Grenzfestlegeabschnitt die Ortsinformation der wenigstens einen Grenze auf Grundlage eines Ortes erzeugt, der von dem Bediener auf dem an dem Anzeigeabschnitt (214) präsentierten tomografischen Bild spezifiziert worden ist.
5. Ultraschalldiagnosevorrichtung nach Anspruch 3, wobei der Grenzfestlegeabschnitt automatisch die Ortsinformation der wenigstens einen Grenze auf Grundlage des empfangenen Signals erzeugt.
6. Ultraschalldiagnosevorrichtung nach Anspruch 5, des Weiteren umfassend einen Speicherabschnitt, der nicht nur die Ortsinformation der wenigstens einen Grenze, sondern auch Information über das tomografische Bild und Information über die Größen
- der Verschiebung der jeweiligen Messpunkte in Verknüpfung mit Zeitpunkten, zu denen die empfangenen Signale eintrafen, oder der Reihenfolge, in der dies erfolgte, speichert.
7. Ultraschalldiagnosevorrichtung nach Anspruch 6, wobei die Information über das tomografische Bild aus dem Speicherabschnitt zur Präsentation des tomografischen Bildes an dem Anzeigeabschnitt (214) gelesen wird und der Grenzfestlegeabschnitt die Ortsinformation der wenigstens einen Grenze zwischen den Geweben aus dem Speicherabschnitt liest und
wobei der Grenzfestlegeabschnitt den Ort der wenigstens einen Grenze auf Grundlage des Ortes aktualisiert, der von dem Bediener auf dem an dem Anzeigeabschnitt (214) präsentierten tomografischen Bild spezifiziert worden ist.
8. Ultraschalldiagnosevorrichtung nach Anspruch 3, wobei der Grenzfestlegeabschnitt automatisch die Ortsinformation der wenigstens einen Grenze auf Grundlage des empfangenen Signals erzeugt und die Ortsinformation der wenigstens einen Grenze aktualisiert, die auf Grundlage des Ortes erzeugt wird, der von dem Bediener auf dem an dem Anzeigeabschnitt (214) präsentierten tomografischen Bild spezifiziert worden ist.
9. Ultraschalldiagnosevorrichtung nach Anspruch 1, wobei der Eigenschaftswert ein elastischer Modul ist.
10. Ultraschalldiagnosevorrichtung nach Anspruch 1, des Weiteren umfassend einen Untersuchungsbereichsbezeichnungsabschnitt (209) zum Befähigen des Bedieners, einen Untersuchungsbereich innerhalb des Messbereiches auf Grundlage des an dem Anzeigeabschnitt präsentierten tomografischen Bildes zu bezeichnen, und
wobei der Eigenschaftswertberechnungsabschnitt (207) einen Eigenschaftswert des Objektes auf Grundlage der Größe der Verschiebung eines Messpunktes innerhalb des Untersuchungsbereiches berechnet.
11. Ultraschalldiagnosevorrichtung nach Anspruch 10, wobei der Eigenschaftswertberechnungsabschnitt (207) des Weiteren wenigstens eines von dem Durchschnitt, Maximalwert, Minimalwert und der Varianz der elastischen Module innerhalb des Untersuchungsbereiches berechnet.
12. Ultraschalldiagnosevorrichtung nach Anspruch 10, wobei der Eigenschaftswertberechnungsabschnitt (207) des Weiteren die Verteilung der elastischen Module innerhalb des Untersuchungsbereiches ausrechnet und die Verteilung der elastischen Mo-

dule als Histogramm an dem Anzeigeabschnitt präsentiert.

13. Ultraschall Diagnosevorrichtung nach Anspruch 1, wobei die Gefäßwand eine Intima, eine Media und eine Adventitia beinhaltet und wobei die wenigstens eine Grenze wenigstens eine von einer Grenze zwischen der Intima und der Media und einer Grenze zwischen der Media und der Adventitia ist.

14. Verfahren zum Steuern einer Ultraschall Diagnosevorrichtung unter Verwendung eines Steuerabschnittes der Vorrichtung, wobei das Verfahren die nachfolgenden Schritte umfasst:

- A) Betreiben einer Ultraschallsonde (201) und Aussenden einer Ultraschallwelle;
- B) Empfangen einer reflektierten Welle von einem Objekt, das eine arterielle Gefäßwand beinhaltet, an der Ultraschallsonde (201), wodurch ein empfangenes Signal erzeugt wird;
- C) Berechnen der Größe der Verschiebung eines jeden Messpunktes in einem Messbereich an der Gefäßwand durch Analysieren des empfangenen Signals;
- D) Festlegen wenigstens einer Grenze zwischen mehreren Geweben in der Gefäßwand, die in dem Messbereich beinhaltet sind, und Auswählen eines von wenigstens zwei Gebieten, die von der festgelegten Grenze getrennt worden sind;
- E) Berechnen eines Eigenschaftswertes des Objektes auf Grundlage der Größe der Verschiebung eines jeden Messpunktes; und
- F) Präsentieren der Eigenschaftswerte der in dem wenigstens einen Gebiet beinhalteten Messpunkte als zweidimensionales Bild.

15. Verfahren nach Anspruch 14, wobei Schritt D) die nachfolgenden Schritte beinhaltet:

- D1) Festlegen wenigstens einer Grenze zwischen den in der Gefäßwand beinhalteten mehreren Geweben; und
- D2) Auswählen eines der wenigstens zwei Gebiete, die von der festgelegten Grenze getrennt worden sind, und wobei Schritt D2) ein Erzeugen der Ortsinformation des einen Gebietes entsprechend einem Bedienerbefehl beinhaltet.

16. Verfahren nach Anspruch 15, des Weiteren umfassend die nachfolgenden Schritte:

- G) Erzeugen eines tomografischen Bildes des Messbereiches des Objektes auf Grundlage des empfangenen Signals; und
- H) Präsentieren des tomografischen Bildes.

17. Verfahren nach Anspruch 14, wobei Schritt D1) ein Erzeugen von Ortsinformation der wenigstens einen Grenze auf Grundlage eines Ortes, der von dem Bediener auf dem tomografischen Bild spezifiziert worden ist, beinhaltet.

18. Verfahren nach Anspruch 16, wobei Schritt D1) ein automatisches Erzeugen der Ortsinformation der wenigstens einen Grenze auf Grundlage des empfangenen Signals beinhaltet.

19. Verfahren nach Anspruch 18, des Weiteren zwischen Schritten D) und E) umfassend:

den Schritt 1) des in dem Speicherabschnitt erfolgenden Speicherns nicht nur der Ortsinformation der wenigstens einen Grenze, sondern auch von Information über das tomografische Bild und von Information über die Größen der Verschiebung der jeweiligen Messpunkte in Verknüpfung mit Zeitpunkten, zu denen die empfangenen Signale eintrafen, oder der Reihenfolge, in der dies erfolgte.

20. Verfahren nach Anspruch 19, des Weiteren zwischen Schritten D) und E) umfassend:

den Schritt J) des Lesens der Information über das tomografische Bild aus dem Speicherabschnitt zur Präsentation des tomografischen Bildes an dem Anzeigeabschnitt und des Veranlassens, dass der Grenzfestlegeabschnitt die Ortsinformation der wenigstens einen Grenze zwischen den Geweben aus dem Speicherabschnitt abrufen, und den Schritt K) des Aktualisierens der Ortsinformation der wenigstens einen Grenze, indem dem Bediener ermöglicht wird, den Ort der wenigstens einen Grenze auf dem tomografischen Bild zu modifizieren.

Revendications

1. Appareil de diagnostic par ultrasons comprenant :

une section de transmission (202) pour commander une sonde ultrasonique qui envoie une onde ultrasonore vers une région de mesure d'un sujet, la région comprenant une paroi de vaisseau artériel ;

une section de réception (203) pour recevoir une onde réfléchie produite en captant au moyen de la sonde ultrasonique l'onde ultrasonore réfléchie par le sujet, générant ainsi un signal reçu ;

une section de détection de déplacement (206) pour calculer la grandeur de déplacement de chaque point de mesure dans la région de me-

- sure sur la paroi vasculaire en analysant le signal reçu ;
 une section de détermination de tissu à présenter (210), qui définit au moins une délimitation entre de multiples tissus de la paroi vasculaire qui sont inclus dans la région de mesure, et qui sélectionne l'une d'au moins deux zones qui ont été divisées par la délimitation définie ; et
 une section de calcul de valeur de propriété (207) pour calculer une valeur de propriété du sujet en fonction de la grandeur de déplacement de chacun desdits points de mesure, dans lequel l'appareil est configuré pour présenter la distribution de valeurs de propriété des points de mesure inclus dans la zone qui a été sélectionnée par la section de détermination de tissu à présenter sous forme d'une image bidimensionnelle.
2. Appareil de diagnostic par ultrasons selon la revendication 1, dans lequel la section de détermination de tissu à présenter (210) comprend :
- une section de définition de délimitation pour définir au moins une délimitation entre les multiples tissus inclus dans la paroi vasculaire ; et
 une section de sélection de zone (212) pour sélectionner l'une d'au moins deux zones qui ont été divisées par la délimitation définie, et dans lequel la section de sélection de zone génère l'information de position de ladite zone conformément à une commande de l'opérateur.
3. Appareil de diagnostic par ultrasons selon la revendication 2, comprenant en outre :
- une section de traitement d'image pour générer une image tomographique de la région de mesure du sujet en fonction du signal reçu ; et
 une section d'affichage (214) pour présenter l'image tomographique.
4. Appareil de diagnostic par ultrasons selon la revendication 3, dans lequel la section de définition de délimitation génère l'information de position de l'au moins une délimitation en fonction d'une position qui a été spécifiée par l'opérateur sur l'image tomographique présentée sur la section d'affichage (214).
5. Appareil de diagnostic par ultrasons selon la revendication 3, dans lequel la section de définition de délimitation génère automatiquement l'information de position de l'au moins une délimitation en fonction du signal reçu.
6. Appareil de diagnostic par ultrasons selon la revendication 5, comprenant en outre une section de stockage qui stocke non seulement l'information de position de l'au moins une délimitation mais aussi de l'information concernant l'image tomographique et de l'information concernant les grandeurs de déplacement des points de mesure respectifs en association avec des points temporels où les signaux reçus sont arrivés ou l'ordre dans lequel ils sont arrivés.
7. Appareil de diagnostic par ultrasons selon la revendication 6, dans lequel l'information concernant l'image tomographique est lue dans la section de stockage pour présenter l'image tomographique sur la section d'affichage (214), et la section de définition de délimitation lit l'information de position de l'au moins une délimitation entre les tissus provenant de la section de stockage, et dans lequel la section de définition de délimitation met à jour la position de l'au moins une délimitation en fonction de la position qui a été spécifiée par l'opérateur sur l'image tomographique présentée sur la section d'affichage (214).
8. Appareil de diagnostic par ultrasons selon la revendication 3, dans lequel la section de définition de délimitation génère automatiquement l'information de position de l'au moins une délimitation en fonction du signal reçu, et met à jour l'information de position générée de l'au moins une délimitation en fonction de la position qui a été spécifiée par l'opérateur sur l'image tomographique présentée sur la section d'affichage (214).
9. Appareil de diagnostic par ultrasons selon la revendication 1, dans lequel la valeur de propriété est un module d'élasticité.
10. Appareil de diagnostic par ultrasons selon la revendication 1, comprenant en outre une section de désignation de région d'intérêt (209) pour permettre à l'opérateur de désigner une région d'intérêt au sein de la région de mesure en fonction de l'image tomographique présentée sur la section d'affichage, et dans lequel la section de calcul de valeur de propriété (207) calcule une valeur de propriété du sujet en fonction de la grandeur de déplacement d'un point de mesure au sein de la région d'intérêt.
11. Appareil de diagnostic par ultrasons selon la revendication 10, dans lequel la section de calcul de valeur de propriété (207) calcule en outre au moins un paramètre parmi la moyenne, la valeur maximale, la valeur minimale et la variance de modules d'élasticité au sein de la région d'intérêt.
12. Appareil de diagnostic par ultrasons selon la revendication 10, dans lequel la section de calcul de valeur de propriété (207) détermine en outre la distribution de modules d'élasticité au sein de la région d'intérêt et présente la distribution de modules d'élasticité

sous forme d'un histogramme sur la section d'affichage.

13. Appareil de diagnostic par ultrasons selon la revendication 1, dans lequel la paroi vasculaire comprend une intima, une media et une adventice et dans lequel l'au moins une délimitation est au moins une délimitation parmi une délimitation entre l'intima et la media et une délimitation entre la media et l'adventice. 5
14. Procédé de contrôle d'un appareil de diagnostic par ultrasons à l'aide d'une section de contrôle de l'appareil, le procédé comprenant les étapes consistant à : 10
 - A) commander une sonde ultrasonique (201) et envoyer une onde ultrasonore ;
 - B) recevoir une onde réfléchie par un sujet, y compris une paroi de vaisseau artériel, à l'aide de la sonde ultrasonique (201), moyennant quoi un signal reçu est généré ; 20
 - C) calculer la grandeur de déplacement de chaque point de mesure dans une région de mesure sur la paroi vasculaire en analysant le signal reçu ; 25
 - D) définir au moins une délimitation entre de multiples tissus dans la paroi vasculaire, qui sont inclus dans la région de mesure, et sélectionner l'une d'au moins deux zones qui ont été divisées par la délimitation définie ; 30
 - E) calculer une valeur de propriété du sujet en fonction de la grandeur de déplacement de chacun desdits points de mesure ; et
 - F) présenter les valeurs de propriété des points de mesure inclus dans l'au moins une zone sous forme d'une image bidimensionnelle. 35
15. Procédé selon la revendication 14, dans lequel l'étape D) comprend l'étape consistant à : 40
 - D1) définir au moins une délimitation entre les multiples tissus inclus dans la paroi vasculaire ; et
 - D2) sélectionner l'une desdites au moins deux zones qui ont été divisées par la délimitation définie, et 45

dans lequel l'étape D2) comprend la génération de l'information de position de ladite zone conformément à une commande de l'opérateur. 50
16. Procédé selon la revendication 15, comprenant en outre les étapes consistant à :
 - G) générer une image tomographique de la région de mesure du sujet en fonction du signal reçu ; et 55
 - H) présenter l'image tomographique.

17. Procédé selon la revendication 14, dans lequel l'étape D1) comprend la génération d'information de position concernant l'au moins une délimitation en fonction d'une position qui a été spécifiée par l'opérateur sur l'image tomographique.
18. Procédé selon la revendication 16, dans lequel l'étape D1) comprend la génération automatique de l'information de position de l'au moins une délimitation en fonction du signal reçu.
19. Procédé selon la revendication 18, comprenant en outre, entre les étapes D) et E), l'étape I) de stockage, dans la section de stockage, non seulement de l'information de position de l'au moins une délimitation, mais aussi d'information concernant l'image tomographique et d'information concernant les grandeurs de déplacement des points de mesure respectifs en association avec des points temporels où les signaux reçus sont arrivés ou l'ordre dans lequel ils sont arrivés.
20. Procédé selon la revendication 19, comprenant en outre, entre les étapes D) et E), l'étape J) de lecture de l'information concernant l'image tomographique à partir de la section de stockage pour présenter l'image tomographique sur la section d'affichage, et la commande de la section de définition de délimitation pour qu'elle extraie l'information de position de l'au moins une délimitation entre les tissus provenant de la section de stockage, et l'étape K) de mise à jour de l'information de position de l'au moins une délimitation en permettant à l'opérateur de modifier la position de l'au moins une délimitation sur l'image tomographique.

FIG. 1

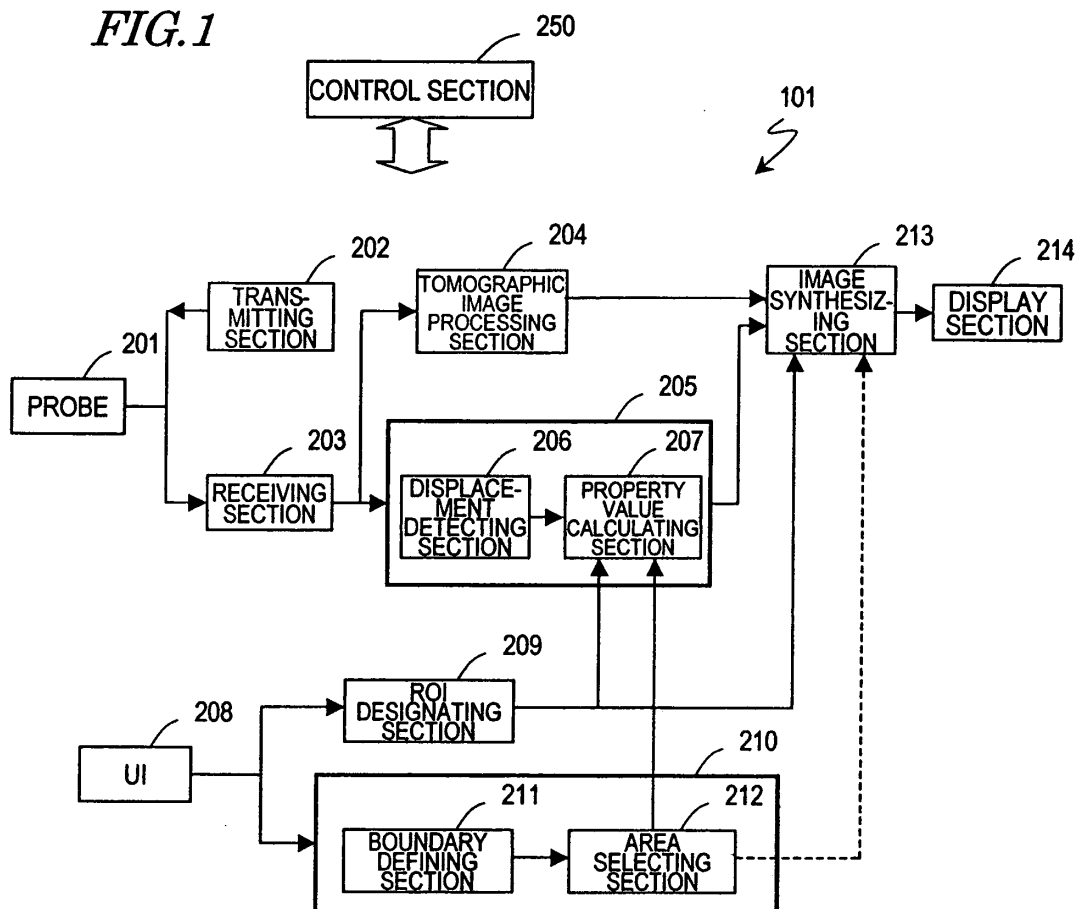


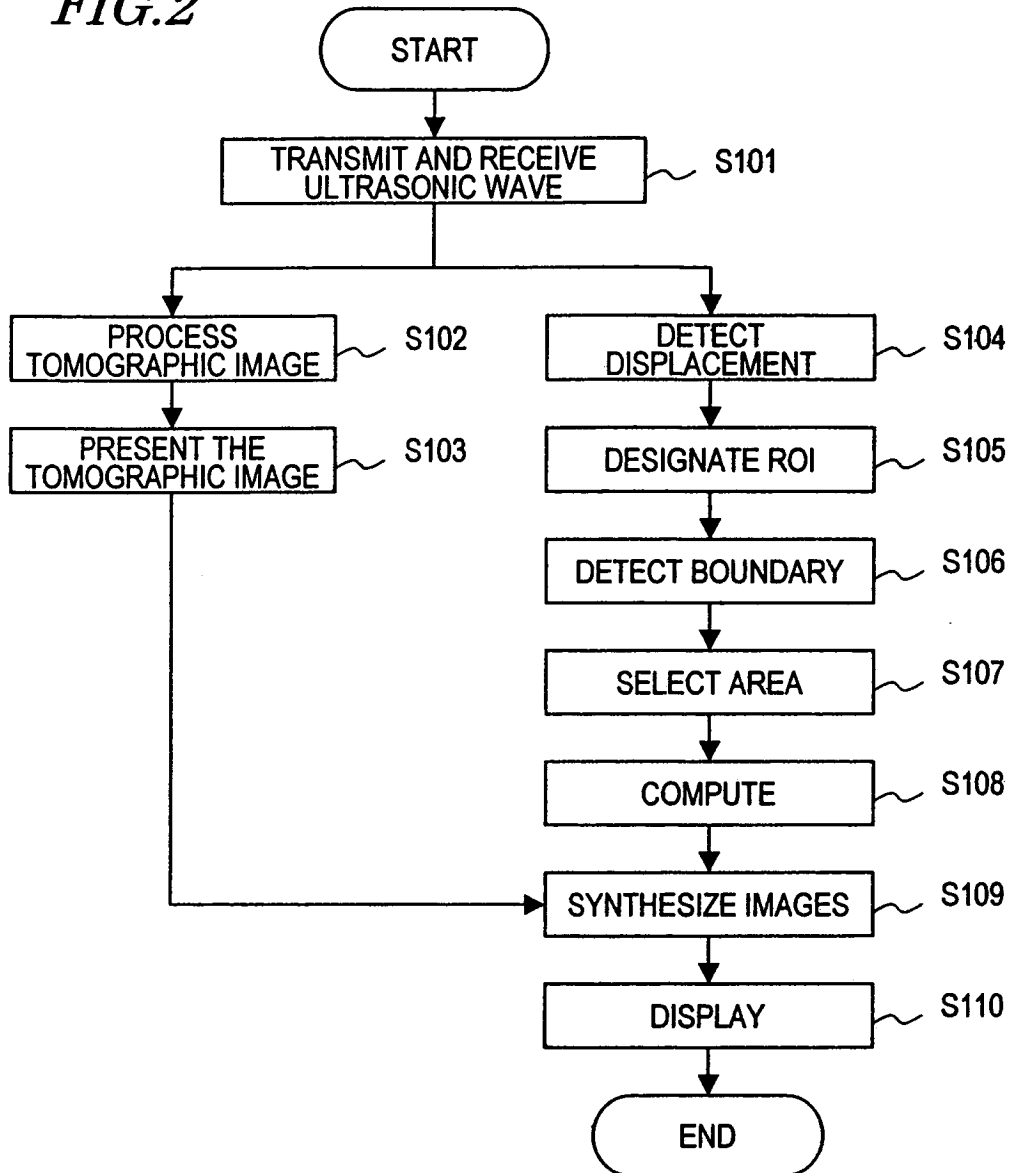
FIG.2

FIG. 3

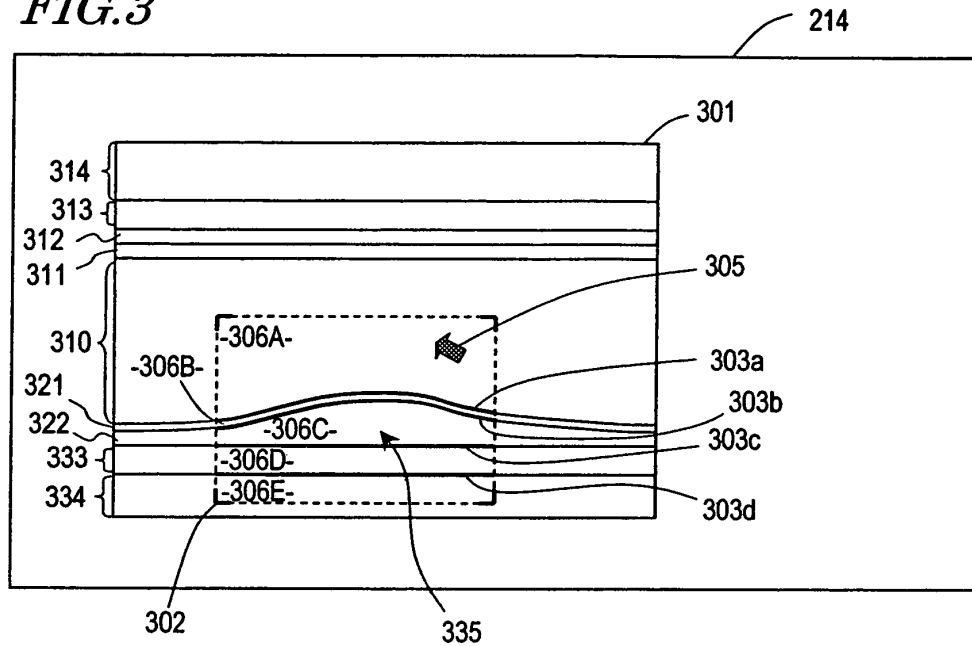


FIG. 4

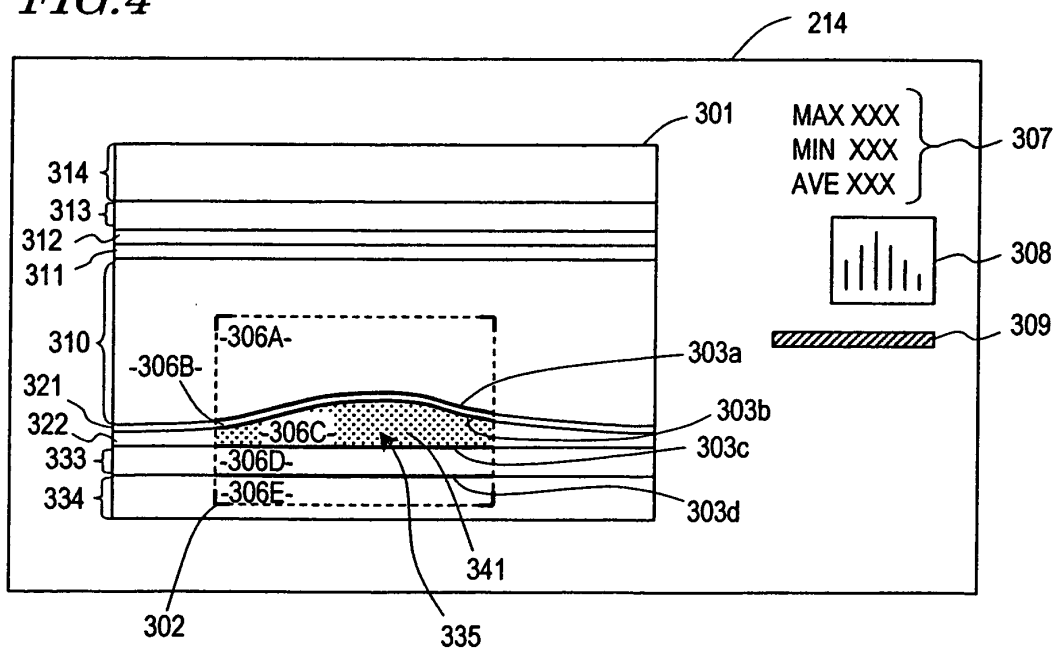


FIG. 5

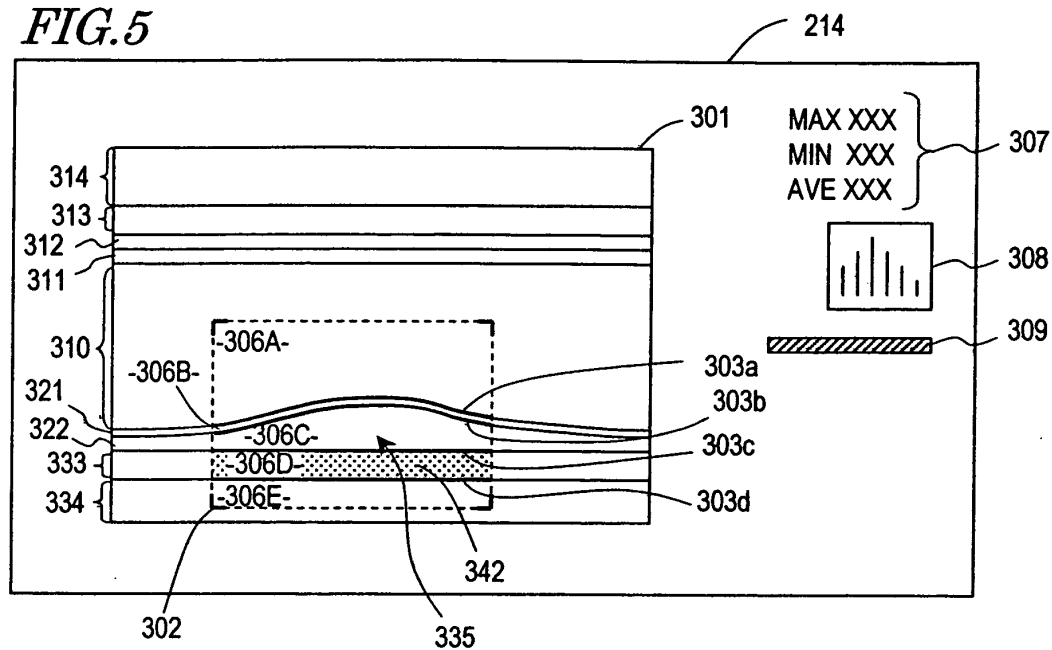


FIG. 6

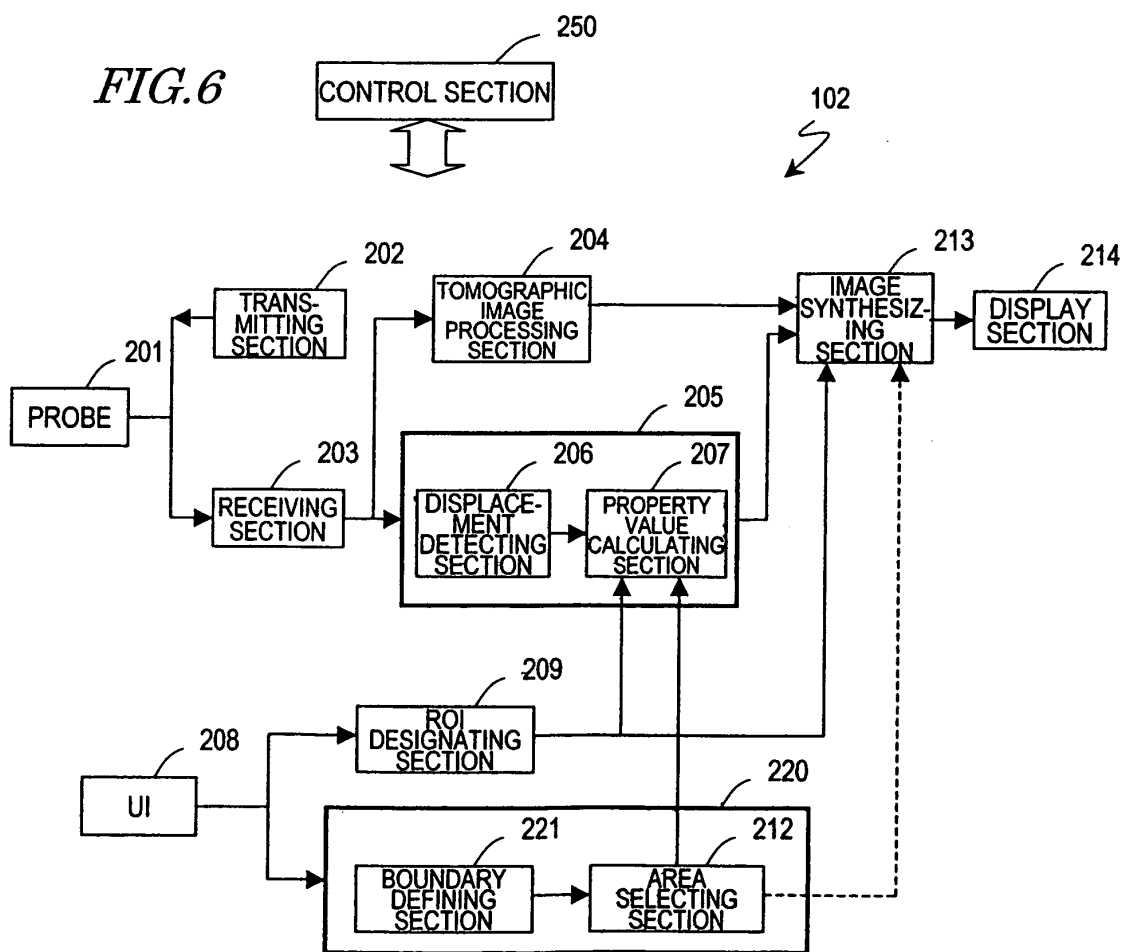


FIG. 7

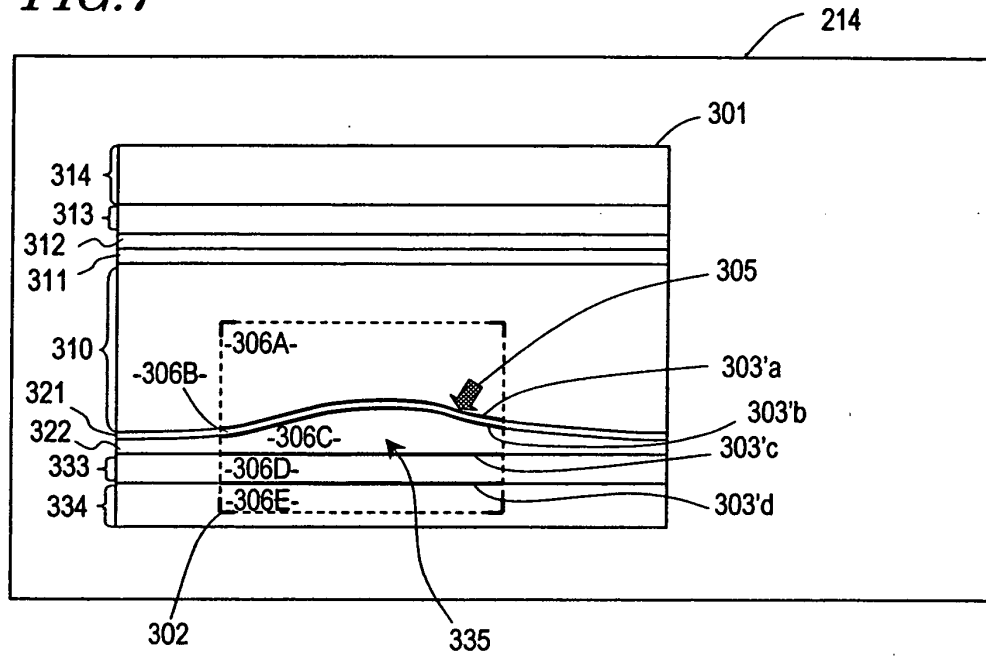


FIG. 8

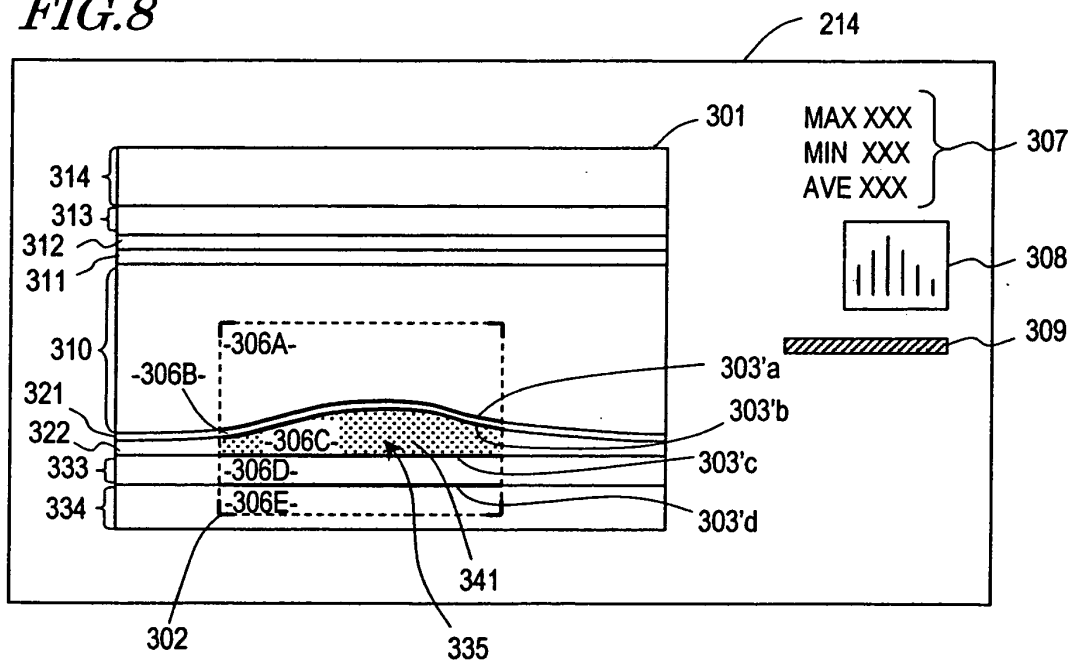


FIG. 9

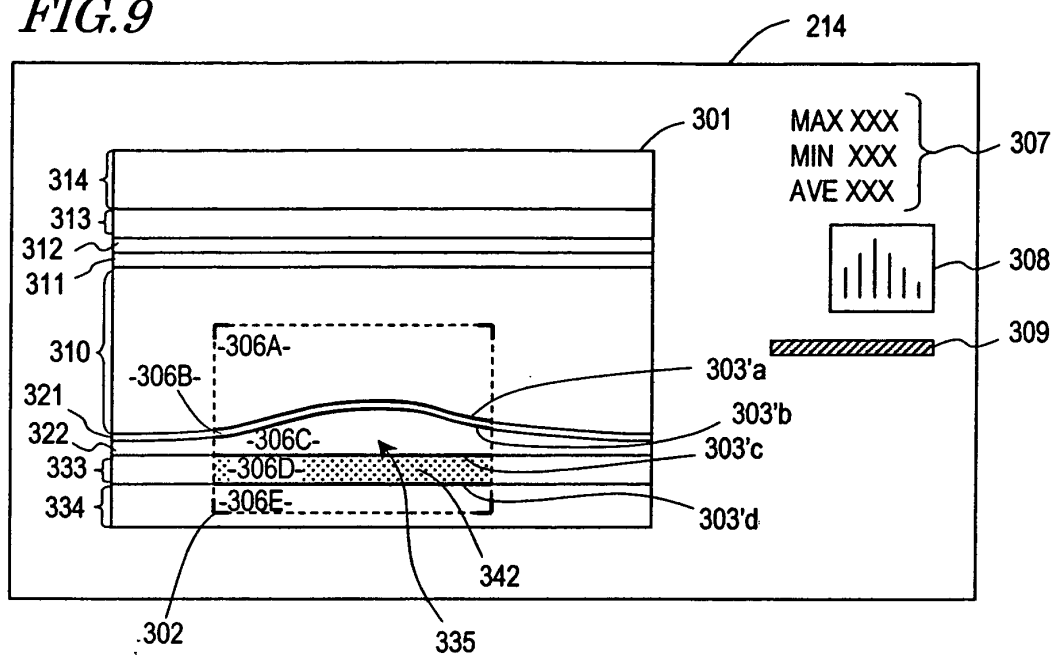


FIG. 10

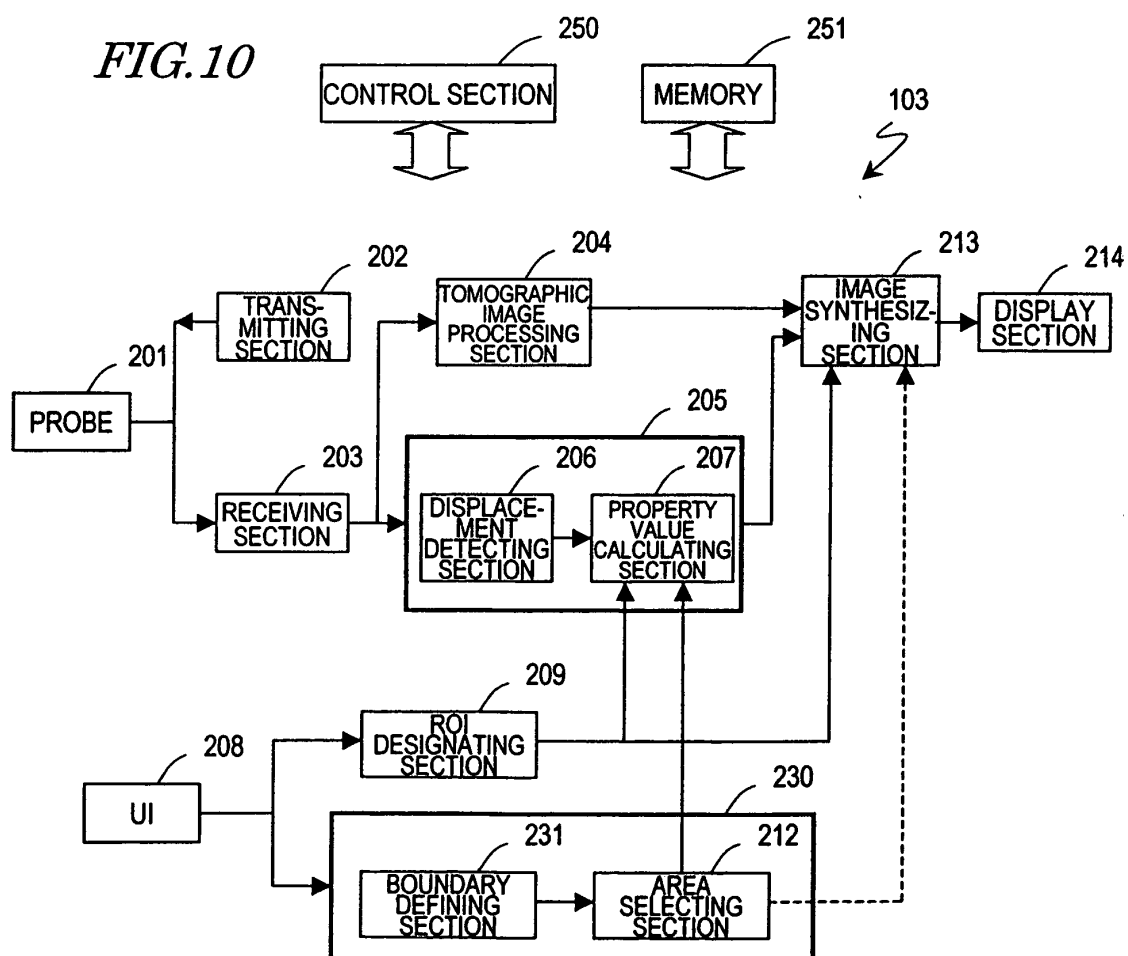


FIG. 11

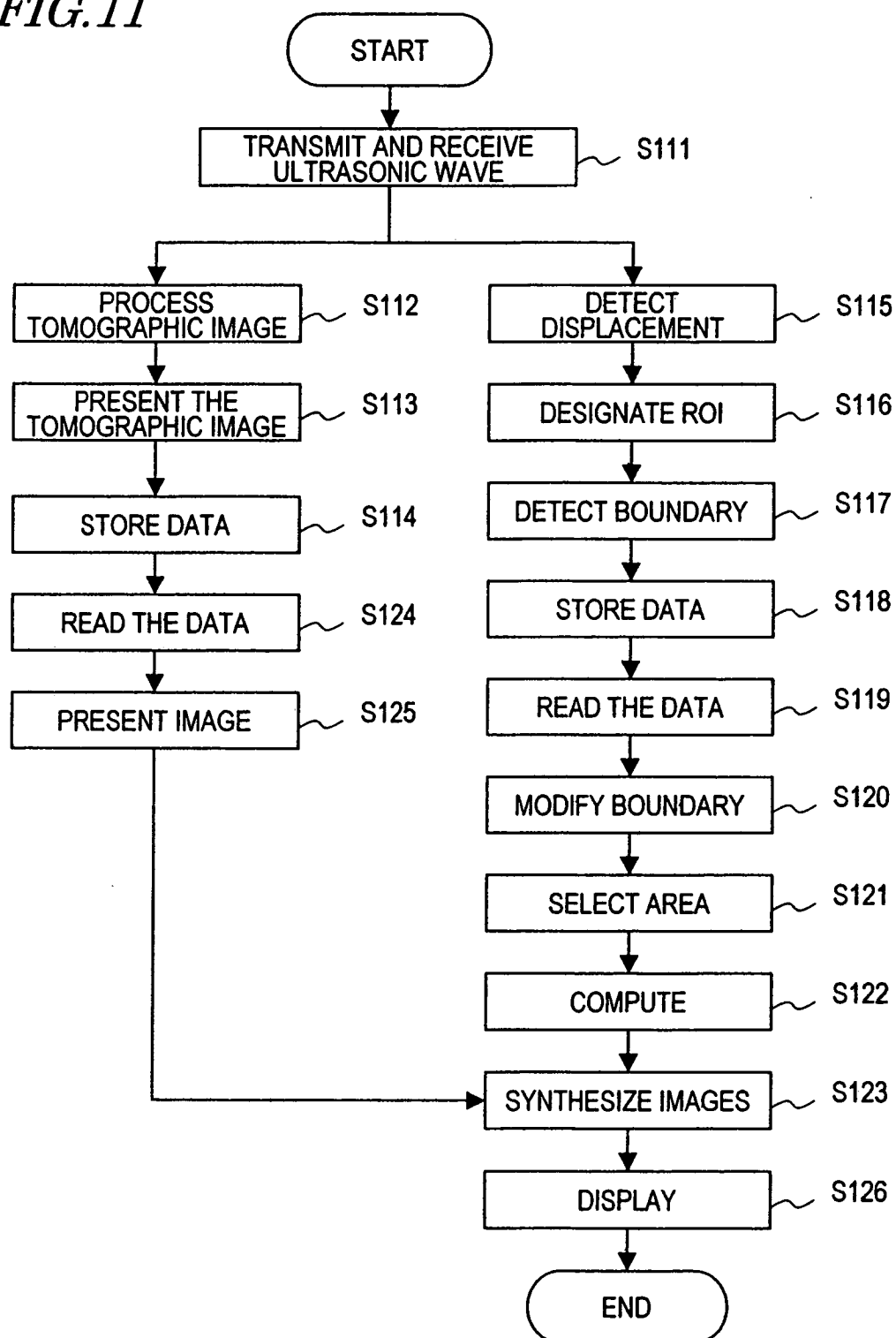


FIG. 12

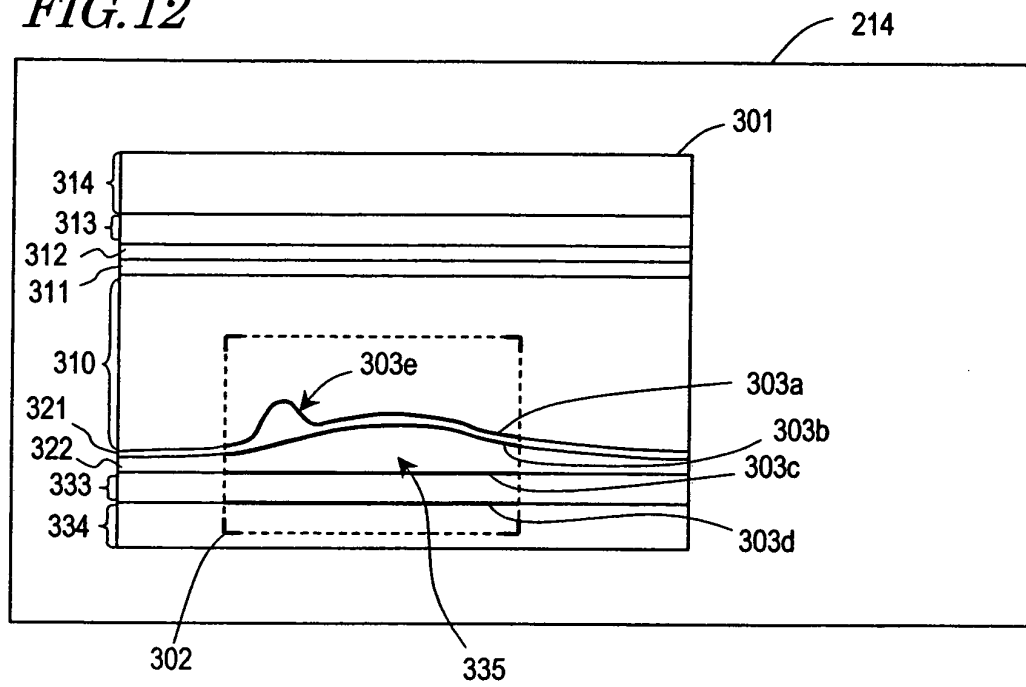


FIG. 13

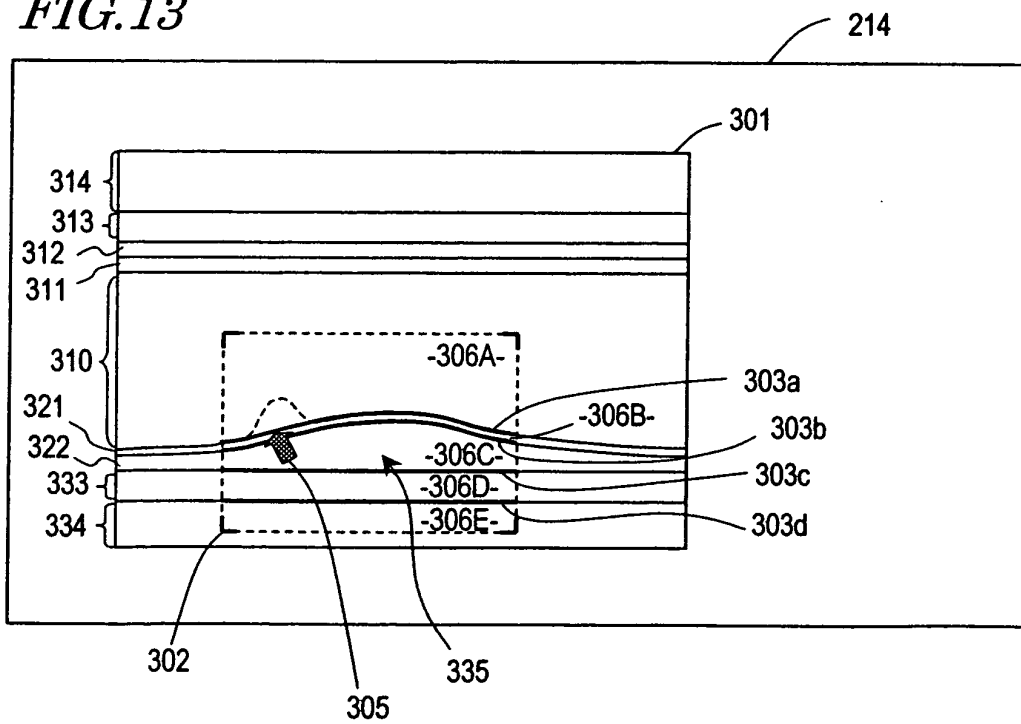
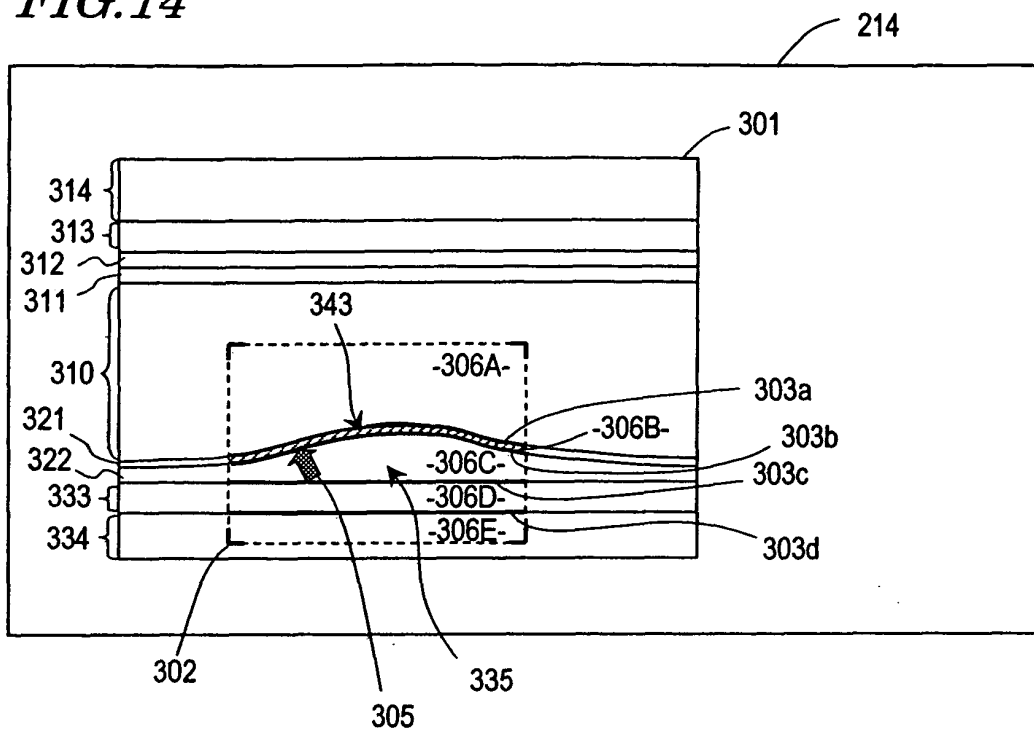


FIG. 14



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- JP 2000229078 A [0004]
- JP 2004112568 PCT [0004]
- JP 2000271117 A [0004]
- EP 1529491 A1 [0004]

根据本发明的超声波诊断装置包括：发送部分，用于驱动超声波探头以向对象的测量区域发送超声波，包括动脉血管壁；接收部分，用于接收在探头处获得从对象反射的超声波产生的反射波，从而产生接收信号；位移检测部分，用于通过分析接收信号计算墙壁上测量区域中每个测量点的位移大小；组织到存在确定部分，其限定包括在壁上的测量区域中的组织之间的至少一个边界，并且选择由限定的边界划分的至少两个区域中的一个；以及特性值计算部分，用于根据每个测量点的位移大小计算对象的特性值。由组织存在确定部分选择的区域中的测量点的特性值的分布被呈现为二维图像。

[illegible]